WHAT IS CLAIMED IS:

1   1.   A video-based animal behavior analysis system, comprising:

2   a computer configured to determine a position and shape of an animal from video

3   images and characterize activity of said animal based on analysis of changes in said

4   position and said shape over time.

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1   2.   The system of claim 1, further comprising:

2   a video camera and a video digitization unit coupled to said computer for capturing

3   said video images and converting said video images from analog to digital format.

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1   3.   The system of claim 2, further comprising:

1   an animal identification, segregation, and tracking module receiving said

2   video images.

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1   4.   The system of claim 3, wherein said computer further includes a behavior

2   identification module for characterizing activity of said animal, said behavior

3   identification module being coupled to said animal identification, segregation, and

4   tracking module.

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1   5.   The system of claim 4, wherein said computer further includes a standard

2   animal behavior storage module that stores information about known behavior of a

3   predetermined standard animal for comparing the activity of said animal, said

4 standard animal behavior storage module being coupled to said behavior identification

5 module.

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1 6.   The system of claim 1, wherein said animal is a mouse.

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1 7.   The system of claim 1, wherein said animal is a rat.

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1 8.   A method of determining and characterizing activity of an animal using

2 computer processing of video images, comprising the steps of:

3 detecting an animal in said video images;

4 tracking changes to said animal over a plurality of said video images;

5 identifying and classifying said changes to said animal; and

6 characterizing said activity of said animal based on comparison to pre-trained models

7 . or rules of such activity or based on calculation of behavioral parameters of

8 behavioral processes and behavioral events..

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1 9.   The method of claim 8, wherein said detecting an animal includes using a

2 background subtraction method comprising the steps of:

3 apply a adaptive or constant threshold on the difference values between a current

4 image and a background so as to determine a broad region of interest;

5 post-process the various pixels in said region of interest to obtain said animal using

6 various morphological and area refinement techniques; and

7 refine contours of said animal image by smoothing.

10. The method of claim 8, wherein said step of identifying and classifying changes to said animal includes using statistical shape information selected from the group consisting of:

area of the animal;

centroid position of the animal;

bounding box and its aspect ratio of the animal;

eccentricity of the animal; and

a directional orientation of the animal relative to an axis as generated with a Principal Component Analysis.

11. The method of claim 8, wherein said steps are also performed in night conditions by using red light to simulate such night conditions, or by using infra-red cameras to capture the images with no light;

12. The method of claim 8, wherein said steps are also performed with a plurality of cages or arenas, each of which contains a single animal;

13. The method of claim 8, wherein said step of characterizing said activity of said animal based on calculation of behavior parameters of behavioral processes and behavioral events includes the steps of:

locating feature points and segments of the said animal;

detecting behavior events by comparing animal feature against predefined rules; and

6   detecting behavior parameters of behavioral processes.

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1   14.   The method of claim 13, wherein said step of locating feature points and

2   segments of the said animal includes the step of detecting body parts of the animal;

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1   15.   The method of claim 14, wherein said body parts include the head;

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1   16.   The method of claim 14, wherein said body parts include the tail;

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2   17.   The method of claim 14, wherein said body parts include the waist;

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4   18.   The method of claim 14, wherein said body parts include the fore body;

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1   19.   The method of claim 14, wherein said body parts include the hind body;

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1   20.   The method of claim 8, wherein said video images include images captured of

2   various animal behavioral analysis apparatuses and said tracking, identifying and

3   characterizing of activities is performed on those animal behavioral analysis

4   apparatuses.

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1   21.   The method of claim 20, wherein said various animal behavioral analysis

2   apparatuses include home cage, a cage looking like a shoebox used for housing

3   animals.

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1   22.   The method of claim 20, wherein said various animal behavioral analysis

2   apparatuses include open field, in various shapes such as circular, square, or

3   rectangular.

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1   23.   The method of claim 20, wherein said various animal behavioral analysis

2   apparatuses include Water Maze, made of a circular pool filled with water and a

3   hidden clear or white Plexiglas platform.

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1   24.   The method of claim 20, wherein said various animal behavioral analysis

2   apparatuses include Y-maze (three-sided runway, where one arm can deliver electrical

3   foot-shock through its floor grid), T-maze (Runways are in the shape of T; its sides

4   are made of black Plexiglas or wood; its floor is metal mesh.), and Radial arm maze

5   (comprised of 8 or 12 arms, radiating from a central start box, made of Plexiglas or

6   wood).

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1   25.   The method of claim 20, wherein said various animal behavioral analysis

2   apparatuses include zero maze, made of brightly lit, open areas alternating with dark,

3   covered areas, comprising the annulus of an elevated circular runway.

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1   26.   The method of claim 20, wherein said various animal behavioral analysis

2   apparatuses include Elevated Plus maze, comprising of four narrow runways, two

3   well lit and open, and two alternating enclosed with walls and dark, and a center box

4   where the animal is placed initially.

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1   27.   The method of claim 20, wherein said various animal behavioral analysis

2   apparatuses include Object Recognition, where multiple objects of different shapes

3   and colors are placed in an open field.

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1   28.   The method of claim 20, wherein said various animal behavioral analysis

2   apparatuses include cued or conditioned fear chambers used for freezing

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1   29.   The method of claim 20, wherein said various animal behavioral analysis

2   apparatuses includes using an unified framework, called "virtual apparatus", which

3   uses a graphic tools to simulate various types of apparatuses.

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1   30.   The method of claim 20, wherein said various animal behavioral analysis

2   apparatuses includes "virtual zones", which are created with graphic tools provided in

3   the system to simulate various types of dividing zones within the apparatuses.

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1   31.   The method of claim 13, wherein said detection of behavioral events includes

2   turning ratio: ratio of path length traveled over number of turns, where number of

3   turns is counted when the animal makes a turn larger than 90 degrees when the animal

4   travels one body length.

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1   32.   The method of claim 13, wherein said detection of behavioral events includes

2   sniffing at objects, an event counted when animal's nose is in contact with an object

3   in a object recognition apparatus

33.   The method of claim 13, wherein said detection of behavioral events includes

stretch-and-attend: Cautious approach with fore body stretched and lowered followed

by the retraction of the fore body.

34.   The method of claim 13, wherein said detection of behavioral events includes

stay-across-areas: partial incursions into particular zones. For example, the animal

might maintain its hind quarters in a closed arm while poking its nose into an open

arm.

35.   The method of claim 13, wherein said detection of behavioral events includes

head dipping, exploratory movement of head/shoulders over the side of the maze.

36.   The method of claim 13, wherein said detection of behavior events includes

the behavior of freezing, and said freezing behavior is determined by the absence of

movement of rodent body for a brief period of time;

37.   The method of claim 13, wherein said detection of behavior events includes

the behavior of locomoting, and said locomotion behavior is determined by the

movement of the rodent around the cage or arena when viewed from the top;

38.   The method of claim 13, wherein said detection of behavior events includes

the behavior of transgressing from zone to another, and said transgression behavior is

3   detected by the movement of a portion of, or the entire body of the rodent across from

4   one defined zone or area into another defined zone or area;

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1   39.   The method of claim 13, wherein said detection of behavior parameters of

2   behavioral processes includes proximity score: calculated by determining the distance

3   of the animal from the goal during each second of the trial and is used as a measure of

4   deviation from the ideal path to the platform once an animal is placed in a water maze

5   setting.

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1   40.   The method of claim 13, wherein said detection of behavior parameters of

2   behavioral processes includes heading errors: defined as an instance of swimming

3   away from the VISIBLE platform in a water maze setting.

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1   41.   The method of claim 13, wherein said calculation of behavior parameters of

2   behavioral processes includes: instant and average speed of movements, distance

3   traveled, its instant and cumulative body turning angles.